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Safety, MTP 6-2-507 and AMCR-385-25. Related MTP's: 8-3-171, AD 871790, 26 May 70 Radiation Detection Equipment 8-3-172, AD 728455, 1 Aug 71 Radiation Survey Equipment.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Gamma Ray, Cobalt 60, Cesium 137, Roentgen
Ionization Chamber, Electrometer
Charge rate, Exposure rate.

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This TOP provides techniques to perform periodic calibration of gamma ray sources used as secondary standards. The personnel must be trained and experienced in Radiac calibration equipment and for that reason the procedures are not step-by-step but are planned to be interpreted by the operator in each instance.

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US ARMY TEST AND EVALUATION COMMAND
GAMMA RAY SOURCE CALIBRATION

DRSTE-RP-702-105 28 March 1980
Test Operations Procedure 6-2-552
AD No. A082639

GAMMA RAY SOURCE CALIBRATION

1. SCOPE

This publication provides techniques to perform periodic calibration of gamma ray sources used as secondary reference standards or as maintenance calibrators. It is to be used by personnel trained and experienced in the use of radiac calibration equipment and radiation principles. It cannot be interpreted as a "procedure," since no one set of step-by-step instructions is applicable to calibrating all gamma ray sources, but will be considered as a TOP for the level of personnel described. Personnel will comply with CFR Title 10, Part 20, NRC License Provisions, Army Radiation Safety Regulations, and S. O. P.'s for facilities used.

1.1 General

Calibration uncertainty. Source gamma rate ±3 1/2 percent (99 percent confidence level).

1.2 Limitations

a. Detailed procedural steps which properly trained personnel can perform without further instructions are not included in this technique. 1/. Reference MTP 6-3-335

1/. Reference MTP 6-3-335

b. Safety requirements are not included in the publication. Reference shall be made to the applicable document(s). 2/. NRC, Title 10.

2. FACILITIES AND INSTRUMENTATION

2.1 A physically secure area or building which is normally used for radiac will be satisfactory for this procedure.

2.2 Instrumentation

2.2.1 Cavity ionization chambers
(e.g., EXRADIN, Shonka or equivalent)

2.2.2 CARY MDL 401 vibrating reed electrometer or equivalent electrometer complete with head adapter and a standard 1,000 pF and 100 pF capacitor.

SPECIFICATIONS:

Sensitivity: 10^{-17} ampere. 2×10^{-5} volts. 5×10^{-16} coulomb.

Ranges: 1 to 300 mV, 1 to 30 volts.

Accuracy: $\pm$0.1 percent $\pm$15 microvolts, METER: $\pm$ percent of full scale, $\pm$2 percent tracking.

Noise: $<4 \times 10^{-16}$ coulomb with input OPEN.

2.2.3 High voltage power supply, (2000 volts maximum), adjustable.

2.2.4 Stop watch - - - Accuracy of $\pm$0.1 percent and 0.1 second readout.

2.2.5 Thermometer. Accuracy of $\pm$.25°C.

2.2.6 Barometer. Accuracy of $\pm$.25 percent.

2.2.7 Appropriate shielded signal cables and connectors.

3. PREPARATION FOR PROCEDURE

3.1 Check for proper positioning and make adjustments, if necessary, on any mechanical equipment, such as exposure table, track or other equipment associated with the gamma ray calibrator.

2/. Reference NRC, Title 10, CFR 150.20.

3.2 Turn on all electronic equipment and allow the minimum warm-up time prescribed by each manual prior to taking any data. A longer warm-up time is desirable in making low level measurements.

3.3 Select either the 1000 pF or 100 pF capacitor and install in place on the electrometer head. For low exposure rates use the 100 pF capacitor, which must be well shielded from the radiation.

3.4 Connect signal cable from input terminal of electrometer head adapter to the appropriate cavity ion chamber.

3.5 Connect high voltage supply to high voltage input of cavity ion chamber.

3.6 Position chamber at appropriate distance from the gamma source with the chamber stem transverse to the gamma ray beam. The centerline of the chamber should coincide with the x-y datum point on the source table, etc. Assure table height and surrounding objects are adjusted/moved to minimize scattered radiation errors.

CAUTION: NEVER TOUCH CHAMBER WITH HIGH VOLTAGE TURNED ON.

3.7 Turn on high voltage supply (either polarity may be used) and allow at least 5 minutes for cable insulation soak-in prior to taking data.

3.8 Follow operating instructions in the electrometer manual.

3.9 Open shorting switch and observe electrometer drift. Drift should not exceed 0.1 mV/min (see appendix).

4. CALIBRATION CONTROLS

4.1 Select a meter range that is compatible with the expected exposure rate.

4.2 Set meter needle slightly below zero.

4.3 Open gamma ray beam shutter.

4.4 Open shorting switch on electrometer while observing needle travel, and start stop watch with needle in coincidence with zero. Stop the watch with needle in coincidence with full scale. Immediately close shorting switch.

5. CALIBRATION AND RECORD

5.1 Record the reading of the stop watch (time should generally be between 30 and 90 seconds). If charge collection rate is either too slow or too fast, change the range selector setting and repeat step (d).

5.2 Repeat steps 4.4 or 5.1 and record the second result. Take a sufficient number of readings at each distance to ensure that the random error in the dose rate is less than 1 1/2 percent at the 99 percent confidence level.* (5 to 7 readings, maximum, if results are variable)

5.3 Close the beam shutter.

5.4 For each exposure, record the reading and distance from the source.

5.5 Atmospheric pressure and temperature must be observed and recorded.

$$*\text{RANDOM ERROR} = \frac{\text{Standard error of the mean (of mV/min runs) x "t" x 100}}{\text{Mean (of mV/min runs)}}$$

NOTE: A programmable pocket computer (e.g., T.I. SR-52) lends itself to rapid and simple R.E. calculations. If the electrometer reads in mA, convert to mV by: MA(R): mV.

6. DATA REDUCTION AND PRESENTATION

6.1 Reduce the data obtained to units of volts per minute (V/min) charge rate.

6.1.1 Multiply the charge rate by the capacitance, the chamber calibration factor, and the pressure-temperature correction factor. This product is the roentgen per hour (R/Hr) exposure rate.

6.1.2 Record the exposure rate for each distance.

6.2 PRESENTATION

6.2.1 Using the exposure rate values obtained in 6.1.2, plot graphs which will enable the user to determine what source distance is required to produce a given exposure rate. A separate graph is required for open beam and for each attenuator used.

6.2.2 From the graph, prepare a chart listing all desired exposure rates and corresponding source distances.

6.2.3 A set of monthly correction factors with instructions for Co60 or other gamma source, will be prepared in order that the exposure values as obtained in 6.2.2 may be retained as the source decays.

6.3 FINAL

6.3.1 Secure all radiation sources and equipment used.

6.3.2 Prepare a calibration report to include a graph, calibration charts and distance correction factors obtained in 6.2.3 above.

6.3.3 Initiate distribution of copies of calibration report as required.

6.3.4 Include any pertinent remarks, comments or problems encountered.

Recommended changes to this publication should be forwarded to Commander, U.S. Army Test and Evaluation Command, ATTN: DRSTE-AD-M, Aberdeen Proving Ground, Md, 21005. Technical information may be obtained from the preparing activity: Commander, U.S. Army Electronic Proving Ground, ATTN: STEEP-MT-I, Ft Huachuca, AZ, 85613. Additional copies are available from the Defense Technical Information Center, Cameron Station, Alexandria,VA 22314. This document is identified by the accession number (AD No.) printed on the first page.

APPENDIX A

CHECK-OFF LIST

1. Facility conforms to the minumum requirements. _____
2. Review instituted safety measures. _____
3. Have safety measures been instituted. _____
4. All instruments are within the calibration period. _____
5. Proper warm-up times allowed. _____
6. Record instrumentation data. _____
7. Record test item data. _____
8. Data reduced. _____
9. Name, grade, MOS Signature (and date) of data observer/recorder. _____

APPENDIX B

DATA RECORD FORM

X-RAY SOURCE CALIBRATION

1. GENERAL

a. Enter all information necessary to identify the test item, the test instruments, and any peculiarities brought out by the test procedures.

b. The Depot Level and Radiological Test Facility Standard sources are the AN/UDM-1, Co60, 1.25 MeV and the AN/UDM-1A Cs137, 0.66 MeV.

2. TEST ITEM/SOURCE (use a separate form page B1 and B2 for each source).

Description _____ Type _____

Nomenclature _____ S/N _____

3. INSTRUMENTATION

Description	Mfg	Model	S/N	Calibration Due Date
a.				
b.				
c.				
d.				
e.				

4. Check all Instrumentation and allow warm-up time for each as appropriate. See section 3 in the text.

CAUTION: Do NOT touch the chamber when HI voltage is ON.

5. Measurement Data Source _____

Expected Exposure Rate _____

Meter Range a._____ b. _____ c. _____ d. _____

Proceed as in Section 4 and 5:

Run No.	Time, Needle Travel	Dist. from Source	Charge V/min Rate	Cap., C	Chamber Calib. Factor	Factor P-T Correct	Rate Exposure R/Hr
1.							
2.							
3.							
4.							
5.							
6.							
7.							

6. Plot each set of data of Distance versus Exposure Rate on semi-log coordinate paper. (See section 6.2.1). A minimum of 1 chart each for open beam, Attenuator No. 1, No. 2, etc. All pertinent data should be noted.

7. A monthly matrix of all charted Distances versus Exposure Rates may be prepared to retain the exposure values as the source decays.

8.

Name _____ Grade _____ MOS _____

Signature _____ Date _____